

## TECHNOLOGICAL CHANGE IN ASSESSING ECONOMICS: A CAUTIONARY WELCOME

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### Biographical Note

Brendan Kennelly is a lecturer in economics at the J.E. Cairnes School of Business and Economics at National University of Ireland (NUI) Galway. He has a strong interest in exploring the use of innovative assessment and learning methods in economics. Brendan was the first lecturer in Europe to use an on-line assessment system known as Aplia in an economics course. His research on the effectiveness of Aplia has been presented at several conferences in Ireland, the UK and the United States. Most of his other recent research has been in mental health economics. He has published papers on the economic cost of suicide and of schizophrenia as well as a paper on preferences for mental health programmes.



John Considine is a lecturer in the Department of Economics, University College Cork (UCC). He obtained his PhD from the University of York and has completed both the Certificate and Diploma in Teaching and Learning in Higher Education delivered by Ionad Bairre at UCC. He was awarded a President's Award for Excellence in Teaching and is a member of the UK Higher Education Academy Economics Network. He has published work in Economic Affairs and the Journal of Economic Education on the use of literature, fiction and humour in the teaching of economics.



Darragh Flannery is a teaching assistant in economics at the Kemmy Business School, University of Limerick. He is also conducting a PhD through NUI Galway and has spent time conducting research at the University of Essex through the European Centre for Analysis in the Social Sciences (ECASS) programme. While his PhD research has focused upon participation and redistribution issues within higher education in Ireland he also has a keen interest in teaching and learning methods within economics, specifically with the use of technology. Darragh has published previously on the topic of the decision of young people in Ireland to enter third level education in Ireland.



### ABSTRACT

The use of computer-based automated assignment systems in economics has expanded significantly in recent years. The most widely used system is Aplia which was developed by Paul Romer in 2000. Aplia is a computer application designed to replace traditional paper-based assignments in economics. The main features of Aplia are: (1) interactive content including problem sets, experiments and news analysis; (2) digital editions of a textbook; (3) assignment sets that are customised to specific textbooks; and (4) immediate feedback for both students and instructors. Its ability to present the dynamics of diagrams and graphs is critical to its use in economics.

This paper analyses the effectiveness of Aplia and traditional paper-based assignments and tutorials using summative assessment results. The analysis is based on a managerial economics course that was taught to over 380 students at NUI Galway in the first semester of 2008-09. The course was designed so that each student was required to complete eight assignments for 25% of the total

marks available for the course. They completed six of the eight assignments by Aplia and the remaining two by paper.

The final exam was organised into eight sections with each section corresponding to a particular assignment. Our basic test is to examine whether a student's performance in a particular section of the exam is affected by whether the student completed the corresponding assignment on paper or online. We also examined if how the student performed on a particular assignment, regardless of the type, predicted how well they did on the corresponding examination question. We found little statistical evidence in support of either hypothesis.

### INTRODUCTION

Economists like to point out that everybody faces trade-offs. A country can spend more on health but will then have less to spend on new cars. An individual can choose to work longer hours but will then have less time to spend with her family. And so it goes with large classes and continuous assessment. A lecturer can assign regular graded assignments to students but will then have little time to do all the other things that a lecturer is supposed to do. Have a look at the first or second chapter of any textbook in introductory economics and you will find a precise definition of opportunity cost as well as a concept called the production possibilities frontier which neatly illustrates the essential concepts of scarcity and choice (Mankiw and Taylor, 2006; Turley *et al.*).

Dismal as it may be, economics also teaches us that trade-offs can change, often dramatically so, over time. Individuals and societies can produce far more goods and services today than they could fifty or a hundred years ago. The reason generally lies in technological change which allows the production possibilities frontier to be pushed out further and further from the origin. The issue we are concerned about in this paper is whether technological change could change the tradeoffs facing lecturers who wish to give regular assignments to large classes.<sup>1</sup>

Economics has long been taught to large classes in first and second year at National University of Ireland (NUI) Galway. Brendan Kennelly has taught either principles of economics (first year) or managerial economics (second year) at NUI Galway since 1998. Like most economics lecturers, he believed that economics is best learned by doing problems and assignments rather than by learning off theories and definitions but felt unable to give regular assignments because they could not be graded. For many years the solution was to give the students a certain number of assignments each semester and to grade only one of them. To ensure that the students had an incentive to do all of the assignments the assignment that was graded was not returned to the students until the semester was finished. But this meant that one of the main goals of assignments – to give students feedback on what they knew and (more importantly) what they did not know – could not be realised. It was a decidedly second best solution.

While Brendan was struggling with large classes in Galway, an economist called Paul Romer was developing an online automatically graded assignment service called Aplia for his economics students at Stanford University. While it was initially designed simply as a product for his own classes Romer quickly realised that other economists might be interested in his product and its use has expanded dramatically in the last ten years.<sup>2</sup> Aplia is now used in well over 1,000 universities around the world. Over 580 million answers have been submitted and

<sup>1</sup> By large classes we mean classes with at least 150 students. Aplia can be used with classes of any size. Our focus on large classes is driven by the fact that managerial economics is taught to large classes at NUI Galway.

<sup>2</sup> In some respects Paul Romer was an unlikely candidate to develop a system of online assignments in economics. He is best known as an economic theorist and his work on what is called new growth theory is widely respected by the profession and will very likely result in him being awarded the Nobel Prize in economics.

automatically graded and every minute about 200 more answers are submitted.

The main features of Aplia<sup>3</sup> are: (1) its interactive content including problem sets, experiments and news analysis; (2) the digital editions of a textbook; (3) the assignment sets that are customized to specific textbooks; and (4) the immediate feedback for both students and instructors. It provides facilities for both formative and summative assessment. Aplia appeals to those with responsibility for educational budgets on the grounds of cost.<sup>4</sup> It also appeals to educationalists who value the direct student interaction with the formative assessment plus immediate feedback on both summative and formative assessment.

In 2006, Brendan Kennelly and his colleague David Duffy became the first economists in Europe to use Aplia. Our aim in this research project is to evaluate the effectiveness of Aplia, by comparing Aplia and traditional paper-based assignments using summative assessment results. Do students learn as much from Aplia as they do from traditional paper-based assignments? We also wanted to find out how students used Aplia and what they thought of it as a learning tool for examination preparation purposes.

### DATA AND ANALYSIS

The research is based on a managerial economics course that was taught to over 380 students at NUI Galway in the first semester of 2008-09. Previous work in this area has yielded mixed results. Nguyen and Trimarchi (2010) found that Aplia, and a similar product, MyEconLab were responsible for increasing the average class mark by about 2% regardless of whether the technology used was a required or optional course component. O'Dea and Ring (2008) found that the percentage of Aplia questions attempted had a significant negative impact on test performance. They also found that the percentage of Aplia questions answered correctly had no effect on test performance. These and other studies on Aplia have compared the performance of one group of students who did assignments on Aplia with another group of students who did assignments on paper (Lee *et al.*, 2010). A unique feature of our analysis is that all of the students were required to do six of their assignments on Aplia and two on paper and had no choice over which assignments to do on paper. The final exam was organised into eight sections with the material examined in each section corresponding to a particular assignment. Our basic question is to examine whether a student's performance in a particular section of the exam is affected (a) by how s/he performed in the corresponding assignment; and (b) by whether the student completed the corresponding assignment on paper or online. We have up to six observations on exam performance for each student with corresponding data on assignment performance.

A panel data set is one where the variable being analysed varies over two dimensions. The variation across both students and sections in exam performance meant that our data could be analysed using panel data techniques. Standard statistical tests indicated that a fixed effects model was appropriate. The dependent variable was the student's performance in each section of the exam and the critical explanatory variables were the student's score in the corresponding assignment and a dummy variable that indicated whether the student had done the assignment on Aplia or on paper. The coefficients on the assignment score and the Aplia/paper dummy were both statistically insignificant (i.e. their p-values are too high). In other words we do not find any evidence that one's performance in an assignment or whether the assignment is done on Aplia or on paper has any effect on how one does in the corresponding section of the exam. We also included a dummy variable for each section to capture common differences across sections. These dummies were all significant. Table 1 contains the detailed econometric results.

<sup>3</sup> For a demonstration about how Aplia works, see [www.aplia.com](http://www.aplia.com). Aplia provides services in disciplines such as statistics, accounting and psychology as well as economics. Aplia offers various pricing options to professors and students. Some institutions have reduced the number of face-to-face recitations after adopting Aplia. Depending on what pricing options are available the total cost of buying the textbook and the Aplia service may be higher or lower for students than just buying the textbook.

**Table 1: Fixed effects model on section-specific exam performance with Aplia/Paper dummy**

Constant	22.28 (0)
Assignment Mark	.003 (.918)
Aplia/paper dummy	-.55 (.35)
Dummy for Section 2	2.8 (.001)
Dummy for Section 3	-2.0 (.04)
Dummy for Section 4	3.22 (.001)
Dummy for Section 5	-7.25 (0)
Dummy for Section 6	-4.11 (0)
Dummy for Section 7	-5.01 (0)
Dummy for Section 8	-3.1 (.001)
Observations	1,351
Sigma_u	7.61
Sigma_e	8.74
rho	0.43

**p-values in parentheses**

**Note: Dependent variable is the score that a student received in each section of the exam**

**Note: Aplia/paper dummy is specified with 1 = assignment completed on aplia and 0 = assignment completed on paper.**

Our analysis indicated that completion rates on the Aplia assignments were higher than on the paper assignments. In a formal statistical model we found that the Aplia/paper dummy had a positive and significant effect on the likelihood that a student completed an assignment in this model. However we did not find any evidence that merely completing an assignment had a positive effect on one's performance in a particular section of the exam<sup>5</sup>.

In the final week of the semester the students were surveyed about their experience with Aplia and the paper assignments. A very substantial majority of students believed that Aplia assignments had a positive effect on their overall understanding of the topics covered in the course and a majority of students believed that they learned more from the Aplia assignments than the paper ones. A majority of students also said that they preferred Aplia to paper assignments. When asked why, only a quarter said they did so because they thought they learned more from Aplia. A much larger percentage said that they preferred Aplia because they found the Aplia assignments easier to complete.

<sup>5</sup> Detailed results are available in Kennelly et al (2010) which contains several more tables of results as well as more detail on the implications of our results. This paper is available on request.

Over 85% of the students said that they would like to use Aplia in other courses. When asked why, the students said they liked having a substantial proportion of the courses awarded for continuous assessment. They also liked the practice assignments on Aplia and said that Aplia was of particular benefit with regards to the use of graphs in economics. This agrees well with an earlier survey by Kennelly and Duffy (2007).

We supplemented the survey with two focus group meetings, one held during the semester and the other held a few months after the final exam. One topic we explored in the second meeting was whether the students regarded Aplia as a good tool to prepare them for examination questions. The students regarded Aplia as more of a complement to a traditional tutorial system than a substitute<sup>6</sup>.

We learned at the first focus group meeting that some of the students regarded the Aplia assignments as puzzles that could be figured out with the aid of textbook or practice assignments rather than pedagogically useful learning devices.

## CONCLUSION

Our statistical analysis revealed little evidence that online assignments were not as good as paper-based assignments in helping students learn key concepts and techniques in a second year economics course. Given that online assignments take up much less of a lecturer's time and given their popularity among students, our evidence indicates that Aplia is a technological improvement that is valuable and one that should be seriously considered by lecturers around the world.

On the other hand, the absence of a positive correlation between performance in assignments and performance in exam section may be regarded as disappointing. One issue that we think needs more consideration is the link between what the students learn in assignments and the kind of questions that students face in exams. This is a key issue for Aplia as the technology restricts the kind of questions that can be asked in the assignments. The Aplia questions tend to be modelled very closely on examples that are worked out in the textbook and students are often able to answer the questions by matching the questions with the corresponding examples in the book.

A unique feature of our paper is that we have up to six observations on exam performance for each student with corresponding data on assignment performance. However this may not have been as important as we thought when we devised the study. It may be the case that students think in a compartmentalised way about assignments and exams (some of the comments in the focus group meetings suggested this). A closer link between assignments and exam performance might be found if there had been one or two midterm examinations in the course with a final exam that focused on the material that had been taught in the final part of the course. Whether that link would be stronger for paper or online assignments remains an open question.

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<sup>6</sup> The complete results from the student survey along with a more detailed analysis of the focus group meetings will be discussed in a separate paper.

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